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DESCRIPTION

SURFACE MOUNTABLE DEVICE

Technical Field

The present invention relates to a surface mountable device that is subjected to a surface mount on a motherboard such as a printed circuit board by, for example, soldering, and more specifically, to a surface mountable device in which the appearance of the bonding state with the motherboard can be visually inspected.

Background Art

Figs. 16 to 19 show examples of the structure of known surface mount devices. Fig. 16 is a perspective view showing the state wherein a surface mount device 30 including side electrodes 33 disposed at the side face of the substrate is mounted on a motherboard 32 (a mount board for a device) by soldering. Fig. 17 is a cross-sectional view taken along imaginary cutting line B-B in Fig. 16. Land electrodes 34 of the motherboard 32 for mounting the surface mount device 30 are generally formed so as to be exposed from the side face of the surface mount device 30 toward the outside by a width a. Thus, the land electrodes 34 are intentionally exposed from the side face toward the outside in order to form solder 35 having a certain thickness at the side face of the surface mount device 30. This structure increases the peel strength of the surface mount device 30.

Fig. 18 is a perspective view showing the state wherein a surface mount device 31 including terminal electrodes 37 disposed at the bottom face of the substrate is mounted on a motherboard 32 by soldering. For example, as disclosed in Patent Document 1, a surface mount device including external connection electrodes in a ball grid array (BGA) structure corresponds to such a surface mount device. Fig. 19 is a cross-sectional view taken along imaginary cutting line C-C in Fig. 18. Land electrodes 34 of the motherboard 32 for mounting the surface mount device 31 are generally disposed at the inside so as not to be exposed from the side face of the surface mount device 31 to the outside. In this structure, solder 35 is not exposed from the side face of the surface mount device 31 toward the outside, thereby improving the packaging density of the motherboard 32. In recent years downsizing has been strongly desired, and the surface mount devices shown in Fig. 18 in which terminal electrodes are disposed at the bottom face of the substrate have attracted attention.

For both these types of surface mount devices such as electronic components, after the surface mount devices are mounted on a motherboard, the appearance is inspected to

confirm the solderability. Regarding the surface mount device 30 shown in Fig. 16, the appearance can be checked by visual inspection 36 because the solder 35 is provided outside of the surface mount device 30. On the other hand, regarding the surface mount device 31 shown in Fig. 18, the appearance cannot be substantially checked by visual inspection because the solder 35 is provided in a narrow clearance between the surface mount device 31 and the motherboard 32. Consequently, Patent Document 2 suggests a method for inspecting the appearance by X-ray transmission.

Patent Document 1: Japanese Unexamined Patent Application Publication No. 8-250620

Patent Document 2: Japanese Unexamined Patent Application Publication No. 10-170455

Disclosure of Invention

Problems to be Solved by the Invention

However, even if the method for inspecting the appearance described in Patent Document 2 can be applied to the surface mount device 31 shown in Fig. 18, the method cannot be easily applied to the actual manufacturing process in terms of the cost because a transmission apparatus required for the appearance inspection by X-ray transmission is expensive.

In order to solve the above problem, it is an object of the present invention to provide a surface mount device in which the appearance of the bonding state such as the solderability of the surface mount device can be readily checked by visual inspection even when, for example, a solder fillet having a certain thickness is not formed on the external surface of the surface mount device and even when a special transmission apparatus is not used.

Means for Solving the Problems

A surface mount device described in claim 1 of the present invention includes a substrate including a first principal face, a second principal face, and a side face connecting the first principal face to the second principal face; a terminal electrode disposed on the first principal face; and a first conductor for appearance inspection extending continuously from the terminal electrode to the side face and having a width smaller than the width of the terminal electrode.

According to a surface mount device described in claim 2 of the present invention, in the invention described in claim 1, the surface mount device further includes a second conductor for appearance inspection disposed on the side face of the substrate, the second conductor for appearance inspection being continuous from the extended end of the first conductor for appearance inspection.

According to a surface mount device described in claim 3 of the present invention,

in the invention described in claim 1 or claim 2, the width of the first conductor for appearance inspection is 100 μm or less.

According to a surface mount device described in claim 4 of the present invention, in the invention described in any one of claims 1 to 3, the first conductor for appearance inspection extends from the terminal electrode to the inside of the substrate.

According to a surface mount device described in claim 5 of the present invention, in the invention described in any one of claims 1 to 4, at least two first conductors for appearance inspection are disposed continuously at the single terminal electrode.

According to a surface mount device described in claim 6 of the present invention, in the invention described in claim 5, the at least two first conductors for appearance inspection are disposed continuously at both ends of the terminal electrode.

As described above, the surface mount device of the present invention includes a substrate having a first principal face, a second principal face, and a side face connecting the first principal face to the second principal face; a terminal electrode disposed on the first principal face; and a first conductor for appearance inspection extending continuously from the terminal electrode to the side face and having a width smaller than the width of the terminal electrode.

In other words, according to this surface mount device, the terminal electrode disposed on the first principal face (i.e., mounting face) is connected to a land electrode disposed on the surface of a motherboard such as a printed circuit board with a bonding material such as solder. The first conductor for appearance inspection extends continuously from the terminal electrode. Therefore, when the surface mount device is connected with the motherboard, the bonding material is applied from the space between the terminal electrode on the mounting face and the land electrode in the upward direction along the first conductor for appearance inspection disposed on the side face. As a result, the presence of the bonding material that is applied upward on the first conductor for appearance inspection can be checked by visual inspection. Thus, the appearance of the bonding state of the surface mount device can be readily inspected.

The width of the first conductor for appearance inspection is smaller than, in particular, one third or less of, the width of the terminal electrode disposed on the mounting face. Accordingly, the amount of bonding material such as the solder applied upward on the first conductor for appearance inspection can be minimized. In addition, the dimension of the bonding material applied upward from the terminal electrode can be increased. For example, the width of the first conductor for appearance inspection is preferably 100 μm or less, more preferably, 80 μm or less. When the width of the first conductor for appearance inspection is 100 μm or less, the amount of bonding material such as the solder applied upward can be increased by capillarity.

Preferably, the second conductor for appearance inspection is disposed along the side face of the substrate and is continuous from the extended end of the first conductor for appearance inspection. Furthermore, the second conductor for appearance inspection preferably extends in the width direction of the first conductor for appearance inspection. The second conductor for appearance inspection is disposed in the direction further extending from the width of the first conductor for appearance inspection. Therefore, the bonding material applied upward on the first conductor for appearance inspection further extends in the width direction according to the second conductor for appearance inspection. As a result, the bonding material applied upward can be visually inspected more reliably.

The first conductor for appearance inspection is preferably disposed such that at least one end of the terminal electrode disposed on the bottom face of the substrate extends continuously to the inside of the substrate and the extended end is disposed at the inside of the substrate. A continuous end face formed by the terminal electrode and the first conductor for appearance inspection is exposed as a part of the side face of the substrate. The first conductor for appearance inspection may be formed by extending both ends of the terminal electrode from the bottom face of the substrate to the inside of the substrate. In such a case, two first conductors for appearance inspection are provided at both ends of the terminal electrode.

Although the substrate is not particularly limited, for example, a multilayer substrate including a plurality of laminated insulating layers is preferable. The insulating layers are composed of, for example, ceramic layers or resin layers such as epoxy resin layers. The ceramic layers used for the insulating layers are preferably prepared by firing a low temperature co-fired ceramic (LTCC) material. The LTCC material can be fired at 1,000°C or less and can be concurrently fired with, for example, silver or copper having a small specific resistance. Examples of the LTCC material include glass composite LTCC materials prepared by mixing a ceramic powder composed of, for example, alumina or forsterite with borosilicate glass; crystallized glass LTCC materials using crystallized glass composed of ZnO-MgO-Al_2O_3-SiO_2; and non-glass LTCC materials using a ceramic powder composed of, for example, BaO-Al_2O_3-SiO_2 or Al_2O_3-CaO-SiO_2-MgO-B_2O_3.

Regarding the terminal electrode, when the insulating layers are resin layers, for example, a metal foil such as a copper foil is preferably used. When the insulating layers are ceramic layers composed of an LTCC material, for example, a conductive paste chiefly composed of silver or copper is preferably used.

Advantages

The invention described in claims 1 to 6 of the present invention can provide a

surface mount device in which the appearance of the bonding state such as the solderability of the surface mount device can be readily checked by visual inspection even when, for example, a solder fillet having a certain thickness is not formed on the external surface of the surface mount device and even when a special transmission apparatus is not used.

Best Mode for Carrying Out the Invention

Preferable embodiments of the surface mount device of the present invention will now be described with reference to Figs. 1 to 15.

First Embodiment

Fig. 1 is a perspective view of a surface mount device of the present embodiment. A surface mount device 1 of this embodiment is composed of, for example, a rectangular ceramic multilayer substrate having a first principal face, a second principal face, and four side faces connecting the first principal face to the second principal face. The multilayer substrate includes three laminated ceramic layers 11 each of which has a thickness of 100 μm.

A terminal electrode 13 is disposed at the first principal face (bottom face) of the ceramic multilayer substrate. A first conductor 12 for appearance inspection that substantially extends perpendicular to the bottom face is disposed on at least one of the four side faces of the ceramic multilayer substrate. The first conductor 12 for appearance inspection extends from the terminal electrode 13 along the side face and is formed continuously with the terminal electrode 13 in the vicinity of the edge between the bottom face and the side face of the undermost ceramic layer.

The first conductor 12 for appearance inspection has a width 14 of as narrow as 80 μm. The first conductor 12 for appearance inspection has a height of 100 μm, which is the same as the thickness of one ceramic layer. The terminal electrode has a width (width in the same direction as the direction of the width of the first conductor 12 for appearance inspection) of 240 μm. A plated gold film is formed by electroless plating on the surfaces of the first conductor 12 for appearance inspection and the terminal electrode 13 to improve the wettability of the solder. In order to achieve a high density arrangement and to provide sufficient connection reliability on a motherboard, the width of the terminal electrode 13 is preferably 100 μm to 1.5 mm, more preferably, 200 to 700 μm.

Fig. 2 is a perspective view showing the state immediately before the surface mount device 1 shown in Fig. 1 is mounted on a motherboard 15. A plated gold film is disposed on the surface of a land electrode 16 of the motherboard 15. Furthermore, a solder film 17 is printed on the gold film. The surface mount device 1 is positioned on

such a motherboard 15. Subsequently, all the components are heated to melt the solder film 17 on the land electrode 16. The terminal electrode 13 of the surface mount device 1 is connected to the land electrode 16 of the motherboard 15 to mount the surface mount device 1 on the motherboard 15. In this step, the surface mount device 1 is mounted such that the side face of the surface mount device 1 is matched with the edge of the land electrode 16 and the land electrode 16 is not exposed from the side face of the surface mount device 1.

Fig. 3 is a cross-sectional view of the surface mount device 1 and the motherboard 15 after the mounting taken along imaginary cutting line A-A in Fig. 2. As shown in Fig. 3, the solder film 17 crosses the edge between the bottom face and the side face of the ceramic multilayer substrate and is thinly applied upward in the vicinity of the upper end of the first conductor 12 for appearance inspection. Unlike a general side electrode, the first conductor 12 for appearance inspection has a narrow and small size, that is, has a width 14 of 100 μm and a height of 100 μm. Therefore, even when the minimum amount of the solder film 17 for connecting the terminal electrode 13 is printed, the solder film 17 can be applied upward in the vicinity of the upper end of the conductor 12 for appearance inspection.

Fig. 4 is an enlarged view of the surface mount device 1 after the mounting, visually viewed from the side face on which the first conductor 12 for appearance inspection is formed. As shown in Fig. 4, the solder film 17 is applied from the terminal electrode 13 side and is applied upward along the first conductor 12 for appearance inspection that is disposed perpendicular to the bottom face of the ceramic multilayer substrate and has the plated gold film disposed thereon. The first conductor 12 for appearance inspection appears gold due to the plated gold film, whereas the solder film 17 appears silver. Accordingly, the application of the solder film 17 in the upward direction is readily distinguished as a result of the difference in the color of both components. Thus, the presence of the solder can be readily checked by visual inspection. Furthermore, since the first conductor 12 for appearance inspection substantially has an upright rectangular shape, the application in the upward direction can be readily determined in terms of the height of the solder. Thus, in the appearance inspection, the degree of solderability can be estimated by checking the wetting of the solder in the upward direction.

In the present embodiment, the first conductor 12 for appearance inspection having a height of 100 μm has been described. The height is not limited to the above so long as the appearance of soldering can be checked by visual inspection. For example, the height of the first conductor 12 for appearance inspection is preferably 5 to 200 μm, more preferably, 20 to 100 μm.

Fig. 5 includes perspective views showing an example of a process for producing the surface mount device of the present embodiment. The process will now be described with reference to Fig. 5.

Firstly, as shown in Fig. 5(a), a ceramic green sheet 41 is prepared. A large ceramic green sheet is generally used in mass production in order to produce many devices at a time. In this embodiment, however, in order to simplify the description of the process, a ceramic green sheet having a size that can provide two sub-substrates is prepared.

As shown in Fig. 5(b), a ceramic green sheet 45, which is disposed at the bottom of a master substrate, is prepared. This ceramic green sheet 45 has the same dimensions as those of the ceramic green sheet 41 shown in Fig. 5(a). A through hole having a diameter of as small as 100 μm or less is formed in the ceramic green sheet 45 such that the center of the through hole is disposed on a sub-substrate parting line 44. A paste chiefly composed of silver or copper is filled in the through hole to form a filled via 42. Furthermore, a conductor film 43, which forms a terminal electrode, is printed so as to cover the filled end of the filled via 42, the filled end being exposed at the lower surface of the ceramic green sheet 45. In addition, the conductor film 43 equally extends to both sides over the sub-substrate parting line 44. According to need, a conductor film forming an internal circuit layer or a via conductor is formed on the other ceramic green sheets 41 to be laminated.

Subsequently, as shown in Fig. 5(c), the ceramic green sheet 45 is disposed at the bottom such that the conductor film 43 is disposed at the lower surface. Other ceramic green sheets 41 are laminated on the ceramic green sheet 45 in a predetermined order. All the ceramic green sheets are bonded by pressing to form a master laminated product 5. The master laminated product 5 includes the conductor film 43 disposed at the bottom thereof.

The master laminated product 5 is fired at a predetermined firing temperature. The resultant fired ceramic product is then divided into two parts along the sub-substrate parting line 44 shown in Fig. 5(c) to form two sub-substrates shown in Fig. 5(d). This division also divides the small filled via 42 in half to expose the conducting face on the side face of each sub-substrate. This exposed conducting face forms the first conductor 12 for appearance inspection in the surface mount device 1.

Subsequently, electronic components such as a semiconductor device and a monolithic capacitor chip are mounted on the sub-substrate (ceramic multilayer substrate). Furthermore, for example, these electronic components are covered with a metal case so as to form the surface mount device 1. When the surface mount device 1 is mounted on the motherboard, the solder film 17 is applied upward on the first conductor 12 for

appearance inspection formed on the side face. The mounting of the surface mount device 1 on the motherboard can be checked by visual inspection of the solder film 17 applied upward. Unlike the known technologies, according to the present invention, even when, for example, a solder fillet having a certain thickness is not formed on the external surface of the surface mount device 1 and even when a special transmission apparatus is not used, the bonding state of the surface mount device 1 by soldering can be readily checked by visual inspection of the solder film 17 applied upward on the first conductor 12 for appearance inspection. In addition, according to the present invention, a large solder fillet need not be formed, thereby increasing the packaging density of the surface mount device 1.

Second Embodiment

Fig. 6 is a perspective view of a surface mount device of the present embodiment. In the description of this embodiment, components that are the same as or corresponding to those in the first embodiment have the same reference numerals. In addition to a first conductor 12 for appearance inspection, a surface mount device 2 of the present embodiment includes a second conductor 18 for appearance inspection. Other parts are formed according to the first embodiment.

In this embodiment, the second conductor 18 for appearance inspection extends from the upper extended end of the first conductor 12 for appearance inspection. The second conductor 18 for appearance inspection is a conductor film having an elongated shape and is disposed in the direction substantially parallel to the bottom face of the ceramic multilayer substrate. The second conductor 18 for appearance inspection is disposed continuously at the upper end of the first conductor 12 for appearance inspection. The combination of the first and the second conductors 12 and 18 for appearance inspection substantially forms a T shape. The dimension of the second conductor 18 for appearance inspection in the horizontal direction is preferably, for example, 100 to 300 μm, which is larger than the width of the first conductor 12 for appearance inspection. The thickness (dimension in the height direction) of the second conductor 18 for appearance inspection is preferably 3 to 50 μm. The width and the height of the first conductor 12 for appearance inspection are the same as those in the first embodiment.

Fig. 7 is an enlarged view of the surface mount device 2 after the surface mount device 2 is mounted on a motherboard 15, visually viewed from the side face on which the first and the second conductors 12 and 18 for appearance inspection are formed. In this embodiment, as shown in Fig. 7, the first and the second conductors 12 and 18 for appearance inspection substantially form the T shape as a whole. Accordingly, when a

solder film 17 is applied upward on the first conductor 12 for appearance inspection, as shown in the figure, the solder film 17 is further applied on the entire length in the horizontal direction of the second conductor 18 for appearance inspection. In this embodiment, since the solder film 17 expands to the T shape, the degree of wetting of the solder in the upward direction can be visually distinguished more specifically, compared with the first embodiment having the upright rectangular shape.

Fig. 8 includes perspective views showing an example of a process for producing the surface mount device of the present embodiment. The process will now be described with reference to Fig. 8.

Firstly, as shown in Fig. 8(a), a ceramic green sheet 41 is prepared. In order to simplify the description of the process, a ceramic green sheet 41 having a size that can provide two sub-substrates is prepared as in the first embodiment.

As shown in Fig. 8(b), a ceramic green sheet 45, which is disposed at the bottom of a master substrate, is prepared and a filled via 42 is formed in the ceramic green sheet 45 as in the first embodiment. Furthermore, a conductor film 43, which forms a terminal electrode, is printed so as to cover the filled end of the filled via 42, the filled end being exposed at the lower surface of the ceramic green sheet 45. In addition, the conductor film 43 equally extends to both sides over a sub-substrate parting line 44. According to need, a conductor film forming an internal circuit layer or a via conductor is formed on another ceramic green sheet 41 to be laminated.

As shown in Fig. 8(c), a conductor film 48, which forms the second conductor for appearance inspection, is then printed on a ceramic green sheet 46. The conductor film 48 equally extends to both sides over the sub-substrate parting line 44. The dimension of the conductor film 48 in the direction of the sub-substrate parting line is 200 μm, which is larger than the diameter of the filled via 42. The thickness of the conductor film 48 is 10 μm.

Subsequently, the ceramic green sheet 45 is disposed at the bottom as in the first embodiment. The ceramic green sheet 46 is laminated on the ceramic green sheet 45 such that the conductor film 48 is disposed at the lower surface. Another ceramic green sheet 41 is laminated in a predetermined order. All the ceramic green sheets are bonded by pressing to form a master laminated product 6. As shown in Fig. 8(d), in the master laminated product 6, the conductor film 43 is disposed at the bottom, the conductor film 48 is disposed on the upper surface of the undermost ceramic green sheet 45, and the conductor film 43 and the conductor film 48 are connected through the filled via 42.

The master laminated product 6 is fired at a predetermined firing temperature. The resultant fired ceramic product is then divided into two parts along the sub-substrate parting line 44 shown in Fig. 8(d) to form two sub-substrates shown in Fig. 8(e). This

division also divides the small filled via 42 in half to expose the conducting face on the side face of each sub-substrate. This exposed conducting face forms the first and second conductors 12 and 18 for appearance inspection.

Subsequently, electronic components such as a semiconductor device and a monolithic capacitor chip are mounted on the sub-substrate (ceramic multilayer substrate). Furthermore, for example, these electronic components are covered with a metal case so as to form the surface mount device 2. When the surface mount device 2 is mounted on the motherboard, the solder film 17 is applied upward to the second conductor 18 for appearance inspection through the first conductor 12 for appearance inspection formed on the side face. The mounting of the surface mount device 1 on the motherboard can be checked more specifically by the solder film 17 applied over the second conductor 18 for appearance inspection, compared with the first embodiment.

Third Embodiment

Fig. 9 is a perspective view of a surface mount device of the present embodiment. In the description of this embodiment, components that are the same as or corresponding to those in the above embodiments have the same reference numerals.

As shown in Fig. 9, in a surface mount device 3 of this embodiment, both ends of a terminal electrode 13 disposed at the bottom face of a ceramic multilayer substrate extend upward to the inside of the ceramic multilayer substrate. The bent end faces are exposed on the side face of the ceramic multilayer substrate as first conductors for appearance inspection. Other parts are formed according to the embodiments described above. A plated gold film is formed on the first conductors 12 for appearance inspection as in the first embodiment. Subsequently, the surface mount device 3 is mounted on a motherboard as in Fig. 2 in the first embodiment.

Fig. 10 is an enlarged view of the surface mount device 3 after the surface mount device 3 is mounted on a motherboard 15, visually viewed from the side face on which the first conductors 12 for appearance inspection are formed. In this embodiment, both ends of the terminal electrode 13 disposed at the bottom face of the ceramic multilayer substrate extend to the inside of the ceramic multilayer substrate so as to form slanted portions. The slanted portions are exposed on the side face of the ceramic multilayer substrate and serve as the first conductors 12 for appearance inspection. Thus, the first conductors 12 for appearance inspection are provided continuously at both ends of the terminal electrode 13. As a result, the bonding state between the surface mount device 3 and the motherboard can be checked more reliably. The structure of the surface mount device is not limited to this embodiment. At least three first conductors 12 for appearance inspection may be provided continuously at one terminal electrode 13.

Fig. 11 includes perspective views showing an example of a process for producing the surface mount device of the present embodiment. The process will now be described with reference to Fig. 11.

Firstly, as shown in Fig. 11(a), a ceramic green sheet 41 is prepared. In order to simplify the description of the process, a ceramic green sheet 41 having a size that can provide two sub-substrates is prepared as in the first embodiment.

As shown in Fig. 11(b), a ceramic green sheet 45, which is disposed at the bottom of a master substrate, is prepared. A conductor film 43 that forms a terminal electrode is printed on the ceramic green sheet 45 such that the conductor film 43 equally extends to both sides over a sub-substrate parting line 44. According to need, a conductor film forming an internal circuit layer or a via conductor is formed on the other ceramic green sheets 41 to be laminated.

Subsequently, as shown in Fig. 11(c), a ceramic green sheet 47 used for embedding both ends of the conductor film 43 is prepared. The ceramic green sheet 47 includes an opening 49 having a width smaller than that of the conductor film 43.

Subsequently, as shown in Fig. 11(d), the ceramic green sheet 47 is disposed at the bottom. The ceramic green sheet 45 is laminated on the ceramic green sheet 47. Other ceramic green sheets 41 are laminated on the ceramic green sheet 45 in a predetermined order. The ceramic green sheet 45 is disposed such that the surface on which the conductor film 43 is printed faces the ceramic green sheet 47. In this step, both ends of the conductor film 43 overlap the ceramic green sheet 47.

Fig. 12 is a cross-sectional view in which a master laminated product 7 shown in Fig. 11(d) is divided along the sub-substrate parting line 44. Fig. 12 shows that the ceramic green sheet 47 overlaps both ends of the conductor film 43 and the central portion of the conductor film 43 is exposed through the opening 49 of the ceramic green sheet 47.

As shown in Fig. 11(e), all the laminated ceramic green sheets are bonded by pressing. Fig. 13 is a cross-sectional view in which the master laminated product 7 after the pressure bonding shown in Fig. 11(e) is cut along the sub-substrate parting line 44. Fig. 13 shows that both ends of the conductor film 43 are embedded toward the inside of the master laminated product 7 by the ceramic green sheet 47. In this step, the conductor film 43 has not been fired yet and is resilient. Therefore, the shape of the conductor film 43 is changed without breaking so as to tilt toward the inside of the master laminated product 7, and in addition, the remaining part of the conductor film 43 is aligned at the lower surface of the ceramic green sheet 47.

The master laminated product 7 is fired and is then divided into two sub-substrates along the sub-substrate parting line 44 as in the first embodiment. Thus, the sub-substrate

shown in Fig. 9 is formed. When the sub-substrates are divided, the end face of the conductor film 43 is also exposed on the side face of each sub-substrate. Both of the slanted end portions in the exposed face form the first conductors 12 for appearance inspection.

Subsequently, electronic components such as a semiconductor device and a monolithic capacitor chip are mounted on the sub-substrate (ceramic multilayer substrate). Furthermore, for example, these electronic components are covered with a metal case so as to form the surface mount device 3.

In this embodiment, although the first conductors 12 for appearance inspection are not completely perpendicular to the bottom face of the ceramic multilayer substrate, these first conductors 12 for appearance inspection generally provide an example of a conductor having an upright rectangular shape. In other words, the degree of wetting of the solder in the upward direction can be easily distinguished by visual inspection as in the first embodiment. Furthermore, the terminal electrode 13 is electrically connected to the two first conductors 12 for appearance inspection, which are disposed continuously at both ends of the terminal electrode 13, even in the inside of the ceramic multilayer substrate. In other words, the first conductors 12 for appearance inspection extend toward the inside of the ceramic multilayer substrate in the direction parallel to the bottom face (first principal face) of the ceramic multilayer substrate. As a result, the terminal electrode 13 can be strongly connected to the first conductors 12 for appearance inspection. This structure can improve the connection reliability between the ceramic multilayer substrate and the terminal electrode 13 or the ceramic multilayer substrate and the first conductors 12 for appearance inspection.

Fourth Embodiment

Fig. 14 shows a modification of the third embodiment and is a perspective view of a surface mount device of the present embodiment. In the surface mount device 4 of this embodiment, both ends (leading ends) of first conductors 12 for appearance inspection, which are slanted on the side face of a ceramic multilayer substrate, are disposed in the direction substantially parallel to the bottom face of the ceramic multilayer substrate. These ends form second conductors 18 for appearance inspection. A plated gold film is formed on the first and the second conductors 12 and 18 for appearance inspection as in the first embodiment. Subsequently, the surface mount device 4 is mounted on a motherboard as in Fig. 2 in the first embodiment described above.

Fig. 15 is an enlarged view of the surface mount device 4 after the surface mount device 4 is mounted on a motherboard 15, visually viewed from the side face on which the first and the second conductors 12 and 18 for appearance inspection are formed. A

suitably large conductor film 43 is formed as in the process for producing the surface mount device in the third embodiment described above. As a result, as shown in Fig. 15, the first and the second conductors 12 and 18 for appearance inspection can be formed in which all the conductors are not evenly slanted but both ends 21 are substantially parallel to the bottom face. When the surface mount device 3 shown in Fig. 10 is compared with the surface mount device 4 shown in Fig. 15, the degree of wetting of the solder in the upward direction can be visually distinguished more specifically in the surface mount device 4 because the shape of the first conductors 12 for appearance inspection in Fig. 15 includes portions extending in the horizontal direction (the direction parallel to the bottom face).

The conductor for appearance inspection described in the above embodiments is preferably formed at all the terminal electrodes that are soldered with a mount board. However, the conductor for appearance inspection may be formed at a part of the terminal electrodes that is important for the mounting, for example, only at the terminal electrodes disposed at four corners of a surface mount device.

Industrial Applicability

The present invention can be preferably used in surface mount devices such as electronic components that are mounted on a wiring board such as a motherboard.

Brief Description of the Drawings

[Fig. 1] Fig. 1 is a perspective view showing an embodiment of a surface mount device of the present invention.

[Fig. 2] Fig. 2 is a perspective view showing the state immediately before the surface mount device shown in Fig. 1 is mounted on a motherboard.

[Fig. 3] Fig. 3 is a cross-sectional view showing the state after the surface mount device shown in Fig. 1 is mounted on the motherboard.

[Fig. 4] Fig. 4 is an enlarged side view of the relevant part of the surface mount device shown in Fig. 1 after the surface mount device is mounted on the motherboard.

[Fig. 5] Figs. 5(a) to 5(d) are perspective views showing a process for producing the surface mount device shown in Fig. 1.

[Fig. 6] Fig. 6 is a perspective view showing an embodiment of a surface mount device of the present invention.

[Fig. 7] Fig. 7 is an enlarged side view of the relevant part of the surface mount device shown in Fig. 6 after the surface mount device is mounted on a motherboard.

[Fig. 8] Figs. 8(a) to 8(e) are perspective views showing a process for producing the surface mount device shown in Fig. 6.

[Fig. 9] Fig. 9 is a perspective view showing an embodiment of a surface mount device of the present invention.
[Fig. 10] Fig. 10 is an enlarged side view of the relevant part of the surface mount device shown in Fig. 9 after the surface mount device is mounted on a motherboard.
[Fig. 11] Figs. 11(a) to 11(e) are perspective views showing a process for producing the surface mount device shown in Fig. 9.
[Fig. 12] Fig. 12 is a cross-sectional view showing the state in which a master laminated product shown in Fig. 11(d) is cut along a parting line.
[Fig. 13] Fig. 13 is a cross-sectional view showing the state in which the master laminated product shown in Fig. 11(e) is cut along the parting line.
[Fig. 14] Fig. 14 is a perspective view showing an embodiment of a surface mount device of the present invention.
[Fig. 15] Fig. 15 is an enlarged side view of the relevant part of the surface mount device shown in Fig. 14 after the surface mount device is mounted on a motherboard.
[Fig. 16] Fig. 16 is a perspective view showing the state after a known surface mount device including electrodes at the side face is mounted on a motherboard.
[Fig. 17] Fig. 17 is a cross-sectional view showing the state after the surface mount device shown in Fig. 16 is mounted on the motherboard.
[Fig. 18] Fig. 18 is a perspective view showing the state after a known surface mount device including electrodes at the bottom face is mounted on a motherboard.
[Fig. 19] Fig. 19 is a cross-sectional view showing the state after the surface mount device shown in Fig. 18 is mounted on the motherboard.

Reference Numerals

1, 2, 3, and 4	surface mount device
5, 6, and 7	master laminated product
11	ceramic layer
12	first conductor for appearance inspection
13	terminal electrode
14	width of first conductor for appearance inspection
15	motherboard
16	land electrode
17	solder film
18	second conductor for appearance inspection
21	both ends of first conductor for appearance inspection
42	filled via
43	conductor film (that forms terminal electrode)

48 conductor film (that forms second conductor for appearance inspection)